CRANIAL MEASUREMENTS OF THE COLUMBIAN GROUND SQUIRREL (*SPERMOPHILUS COLUMBIANUS COLUMBIANUS*), WITH SPECIAL REFERENCE TO SUBSPECIES TAXONOMY AND JUVENILE SKULL DEVELOPMENT

Charles L. Elliott[1] and Jerran T. Flinders[2]

ABSTRACT.— The Columbian ground squirrel (*Spermophilus columbianus* (Ord)) is represented by two recognized subspecies, *S. c. columbianus* (Ord) and *S. c. ruficaudus* (A. H. Howell), that occupy allopatric but adjacent geographical areas in Washington, Oregon, and Idaho. Since numerical cranial characteristics of these subspecies have not been documented, we measured 8 cranial characteristics on 94 adult and 32 juvenile Columbian ground squirrels in an area considered to be occupied by *S. c. columbianus*. Body weights and standard body measurements were recorded for adults and juveniles. The study area included portions of the River of No Return Wilderness Area in central Idaho. Howell's (1938) original descriptions seemed to differentiate *S. c. ruficaudus* from our sample of Columbian ground squirrels. Juvenile Columbian ground squirrels did not attain full cranial development until their second season. Length of maxillary tooth row in juveniles, especially females, may closely approximate adult dimensions by the end of their first summer.

There are 11 Holarctic species recognized in the subgenus *Spermophilus* Cuvier and 8 of these occur in North America (Hall 1981:382, Nowak and Paradiso 1983:501). One member of this group is the Columbian ground squirrel (*Spermophilus columbianus* (Ord)), a sciurid endemic to the Pacific Northwest (Fig. 1). Howell (1938) examined specimens of Columbian ground squirrels and separated the species into two subspecies of *S. c. columbianus* (Ord) and *S. c. ruficaudus* (A. H. Howell). The two subspecies are differentiated as follows: (1) coat color: *ruficaudus* is tawny (not gray) on the upper side of the tail, sides of its face and throat are a deeper shade of tawny and its legs and feet are darker; (2) external anatomy: *ruficaudus* have larger hind feet; and (3) cranial characteristics: the skull of *ruficaudus* is larger and relatively broader than *columbianus*, the jugal wider and zygomata more heavily built (Howell 1938).

The cranial dimensions of either subspecies of the Columbian ground squirrel have not been examined. As a result of recent field studies (Elliott and Flinders 1980a,b), we obtained skulls from a large number of adult and juvenile Columbian ground squirrels. The purpose of this note is to report how the measurements obtained from these specimens compare to Howell's criteria for subspeciation and to note the extent of cranial development exhibited by juvenile ground squirrels at the end of their first season of activity.

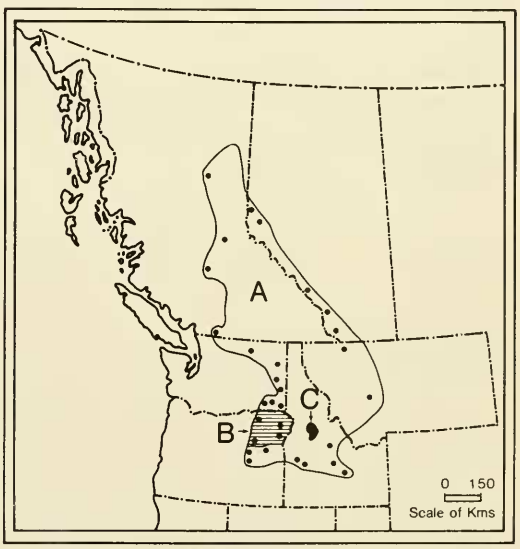

Fig. 1. Range of *Spermophilus columbianus* in North America. Area A represents the range of *S. c. columbianus*; area B represents the range of *S. c. ruficaudus*, and area C indicates location of the Idaho Primitive Area. Black circles correspond to specimen locations used by Hall (1981:389) in establishing subspecies boundaries.

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602. (Current address 301 O'Neill, AES-ALR, Univ. Alaska, Fairbanks, Alaska 99701).
[2]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

STUDY AREA AND METHODS

Ground squirrels were collected from four sites within the Big Creek drainage of the Idaho Primitive Area (IPA) (now called the River of No Return Wilderness Area). Physiography and vegetation of the Big Creek area have been described by Hornocker (1970). The Cold Meadows study site (elev. 2142 m) typified the mountain meadow habitat type utilized by Columbian ground squirrels in the IPA. Rush Point (elev. 1890 m) represented the *Artemisia tridentata*-bunchgrass association typical of the southeast-facing slopes occupied by *S. columbianus*. The Big Creek (elev. 1750 m) and Cabin Creek (1067 m) squirrel colonies were located in unused horse pastures, areas representative of the many abandoned homesteads and ranches found throughout the IPA.

Physical measurements and skull samples were obtained from squirrels live-trapped and shot. Skulls were skinned, dried, and placed in a dermestid beetle (*Dermestes maculatus*) colony for cleaning. Only squirrels meeting the following minimal weight criteria were used in this study: June body weight—400 g, July—500 g, and August—600 g. These categories were used in an attempt to eliminate yearling squirrels from calculations. Mark-recapture data at the Cold Meadows and Rush Point sites indicated one-year-old squirrels emerging from hibernation exhibited early season body weights of approximately 300 g (unpublished data). Michener (1977) also separated age classes of Columbian ground squirrels based on weight, finding that females weighing over 400 g and under 300 g could reliably be classed as adults and yearlings, respectively. It was therefore concluded that use of the aforementioned weight categories (400, 500, 600 g) assured that only adult Columbian ground squirrels would be included in the calculations. Ground squirrels referred to as juveniles in this study are squirrels in their first summer of life (= young of the year). Eight skull parameters (defined in Hall 1981:133–137) were measured (see Table 1). All measurements were taken to the nearest 0.1 mm with dial calipers.

RESULTS AND DISCUSSION

Ninety-four adults and 32 juvenile Columbian ground squirrel skulls of the subspecies

TABLE 1. Cranial measurements (mean ± S.D.) of adult Columbian ground squirrels from four sites in the Idaho Primitive Area and Howell's (1938) data. Sample size in parentheses. Idaho data are for *Spermophilus columbianus columbianus*.

Location	Diastema	Occipito-nasal length	Palatilar length	Zygomatic breadth	Mastodial breadth	Inter-orbital breadth	Nasal length	Maxillary tooth row length
				(Measurements in mm)				
IDAHO PRIMITIVE AREA								
Cold Meadows								
Males (23)	11.8±0.7	51.3±1.9	25.4±0.9	32.2±1.7	25.7±0.9	10.9±0.7	18.2±0.9	11.7±0.4
Females (23)	11.6±0.6	50.4±0.9	25.2±0.6	32.0±0.8	25.1±0.6	10.7±0.7	18.2±1.2	11.5±0.5
Rush Point								
Males (17)	11.7±0.8	51.1±1.9	25.6±0.9	32.6±1.5	25.9±1.4	10.9±0.6	17.3±2.6	11.5±0.4
Females (13)	11.2±0.9	49.3±1.9	24.5±0.8	30.7±2.0	24.9±1.5	10.6±0.7	17.7±1.4	11.6±0.5
Big Creek								
Males (8)	9.9±0.6	46.9±1.5	24.3±0.7	28.9±1.8	23.4±0.6	9.9±0.4	16.1±1.1	11.6±0.5
Cabin Creek								
Males (6)	11.1±0.4	50.0±1.3	25.1±0.8	30.7±0.6	24.4±0.7	10.1±0.4	17.5±0.5	11.8±0.4
Females (4)	11.5±0.8	49.2±1.1	24.8±0.3	31.3±0.7	25.7±2.7	10.5±0.6	17.7±0.8	11.3±0.9
HOWELL'S 1938 DATA								
S. c. columbianus								
Males (10)	°	51.7	25.1	31.8	°	10.6	19.4	10.9
Females (7)	°	50.7	24.8	32.2	°	11.2	18.7	11.1
S. c. ruficaudus								
Males (8)	°	54.2	26.6	34.1	°	12.4	19.8	11.4
Females (4)	°	52.9	25.7	33.3	°	12.5	19.3	11.3

TABLE 2. Cranial measurements (mean ± S.D.) of juvenile Columbian ground squirrels from three sites in the Idaho Primitive Area. Sample size in parentheses. Data for *Spermophilus columbianus columbianus*.

	Sites				
	Cold Meadows		Rush Point		Cabin Creek
Measurement	Males (6)	Females (6)	Males (11)	Females (5)	Females (4)
Diastema	10.8 ± 0.6mm	10.6 ± 0.8	10.3 ± 0.6	9.9 ± 0.6	10.6 ± 0.4
Occipotonasal length	47.4 ± 1.1	46.3 ± 2.0	47.4 ± 2.6	44.9 ± 1.9	47.3 ± 2.2
Palatilar length	23.7 ± 0.5	22.9 ± 1.2	23.9 ± 1.2	21.6 ± 1.6	24.9 ± 0.4
Zygomatic breadth	28.5 ± 1.2	28.9 ± 2.4	27.8 ± 0.7	27.7 ± 0.9	29.1 ± 1.1
Mastodial breadth	23.9 ± 0.6	23.3 ± 1.7	23.1 ± 0.7	22.2 ± 1.1	24.2 ± 0.7
Interorbital breadth	9.8 ± 0.2	9.8 ± 0.5	9.6 ± 0.4	9.5 ± 0.5	9.5 ± 0.6
Length of nasals	16.2 ± 0.9	16.2 ± 0.9	15.7 ± 0.7	15.2 ± 1.3	16.4 ± 1.3
Maxillary tooth row	11.7 ± 0.3	11.6 ± 0.8	11.4 ± 0.5	11.2 ± 0.5	11.6 ± 0.5

S. c. columbianus were measured (Tables 1 and 2). No statistical comparison between our skull measurements and Howell's (1938) data are possible (Howell lists only the category mean and range of values), but certain trends are evident. The mean interorbital breadth, length of nasals, and greatest skull length (occipitonasal length) given by Howell for *ruficaudus* are larger than corresponding values obtained for *columbianus* (Table 1). This would tend to support Howell's subspeciation criteria that *ruficaudus* skulls are larger and broader than *columbianus*. Howell also noted that *ruficaudus* had larger hind

TABLE 3. Mean (± S.D.) total body length, hind foot length, and ear length (mm) of adult Columbian ground squirrels from four sites in the Idaho Primitive Area, two museum collections, and Howell's (1938) data. Sample size in parentheses.

Location	Total body length	Hind foot length	Ear length
IDAHO PRIMITIVE AREA[1]			
Cold Meadows			
Male (64)	334.9 ± 14.2	50.5 ± 1.7	19.7 ± 1.3
Female (72)	326.3 ± 12.4	49.0 ± 1.9	19.2 ± 1.1
Rush Point			
Male (34)	328.2 ± 16.5	49.4 ± 1.8	19.4 ± 1.4
Female (41)	327.5 ± 14.1	46.7 ± 2.1	19.0 ± 1.0
Big Creek			
Male (11)	333.8 ± 16.5	51.4 ± 1.9	19.5 ± 0.7
Female (3)	325.0 ± 15.0	51.3 ± 1.5	19.7 ± 0.6
Cabin Creek			
Male (3)	341.7 ± 7.6	51.3 ± 2.3	19.7 ± 1.2
Female (5)	328.6 ± 10.6	49.6 ± 0.9	20.0 ± 0.7
UNIVERSITY OF IDAHO MUSEUM[1]			
Male (10)	337.6 ± 13.5	49.7 ± 2.0	22.5 ± 3.5
Female (11)	337.3 ± 17.3	48.7 ± 2.0	23.0 ± 2.7
UNIVERSITY OF MONTANA ZOOLOGICAL MUSEUM[1]			
Male (7)	366.1 ± 18.8	52.1 ± 3.7	17.8 ± 2.9
Female (9)	348.4 ± 23.0	47.9 ± 2.9	15.9 ± 3.3
HOWELL'S 1938 DATA			
Spermophilus columbianus columbianus			
Male and female (12)	349.7 (327–377)[2]	51.2 (48–55)	—
Spermophilus columbianus ruficaudus			
Male and female (10)	369.6 (340–410)	54.2 (51–58)	

[1]Data for *Spermophilus columbianus columbianus*.
[2]Range of values given by Howell (1938).

TABLE 4. Skull size of juvenile Columbian ground squirrels expressed as a percent of average skull dimensions of adults taken during the same collection period, August 1977–1978, Idaho Primitive Area.

	Sites				
	Cold Meadows		Rush Point		Cabin Creek
Measurement	Males	Females	Males	Females	Females
Diastema	92	91	88	89	92
Occipitonasal length	92	92	93	91	96
Palatilar length	93	91	94	88	100
Zygomatic breadth	89	90	85	90	93
Mastodial breadth	93	95	89	89	94
Interorbital breadth	90	92	88	90	90
Length of nasals	89	89	91	86	93
Maxillary tooth row	99	100	99	97	100

feet than *columbianus* (Table 3). This characteristic of subspeciation also appears to be valid. Howell's *ruficaudus* hind foot length and associated range of values exceed all values found in Idaho and other locations occupied by *columbianus* (Table 3). Based on data reported here and by Howell (1938), an additional parameter for justifying *ruficaudus* as a valid subspecies is total body length. *Spermophilus c. ruficaudus* appears to be a longer squirrel than *columbianus*, exceeding all reported *columbianus* values for total body length (Table 3).

Juvenile ground squirrels often exhibit a delay in attaining maturity (Bridgwater 1966, Morton and Tung 1970). Juvenile Columbian ground squirrels on the Cold Meadows study site do not attain adult size until their second season (Elliott and Flinders 1980b). This same delay in attainment of adult dimensions is also exhibited in cranial development (Table 4). Of the skull parameters measured, the maxillary tooth row was the closest to adult size at the end of the first summer. Skull length (occipitonasal length) was approximately 92% of adult size and the skull width (zygomatic breadth) was almost 90% (Table 4).

Based on information available in the literature and data reported here, Howell's (1938) criteria used in establishing two subspecies within *Spermophilus columbianus* are valid. Additional data concerning the physical and cranial dimensions of *Spermophilus columbianus ruficaudus* are needed to further establish the validity of the two subspecies.

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